DOCUMENT REVIEW DRAFT

JPL

Planetary Protection for the Mars Sample Return Project

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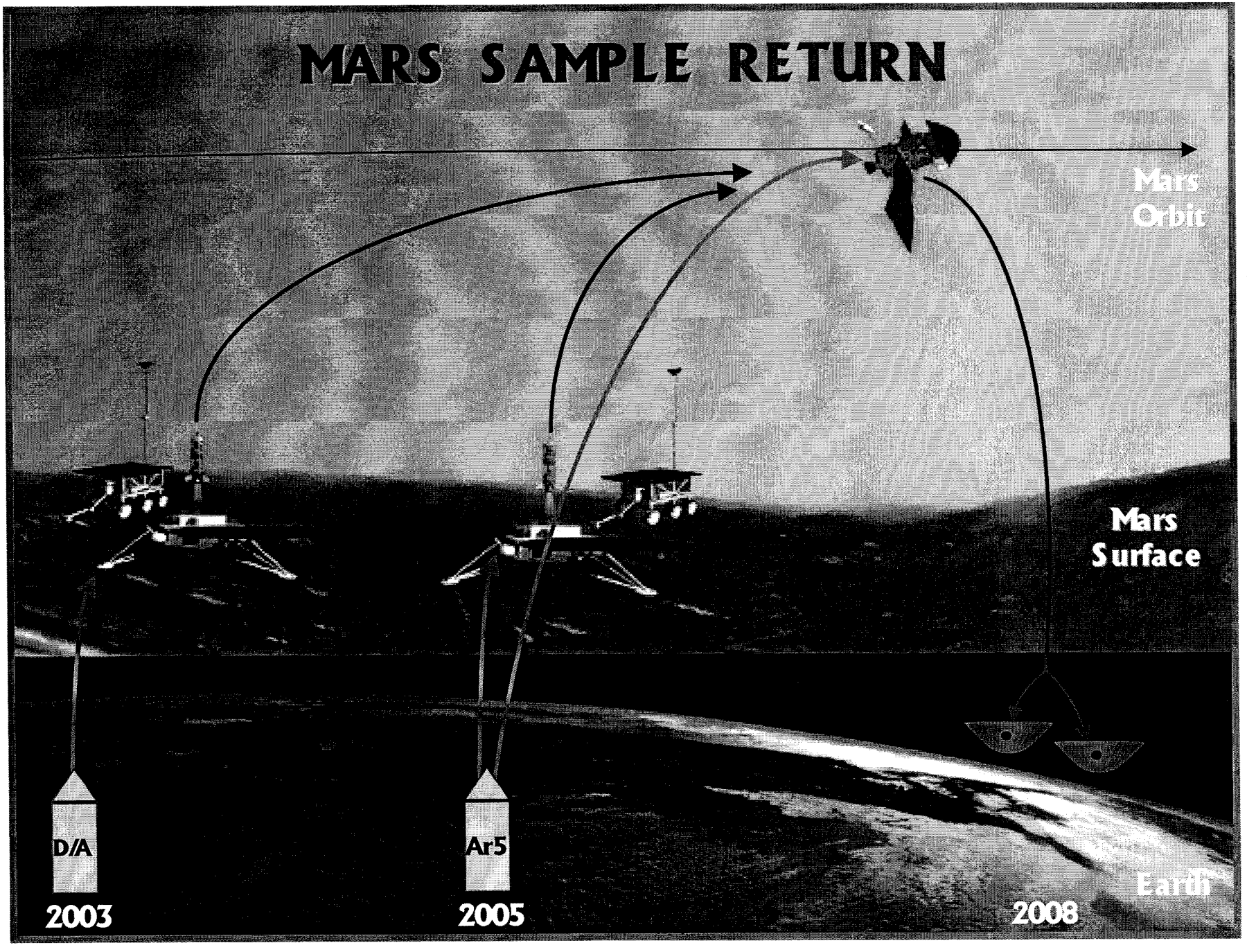
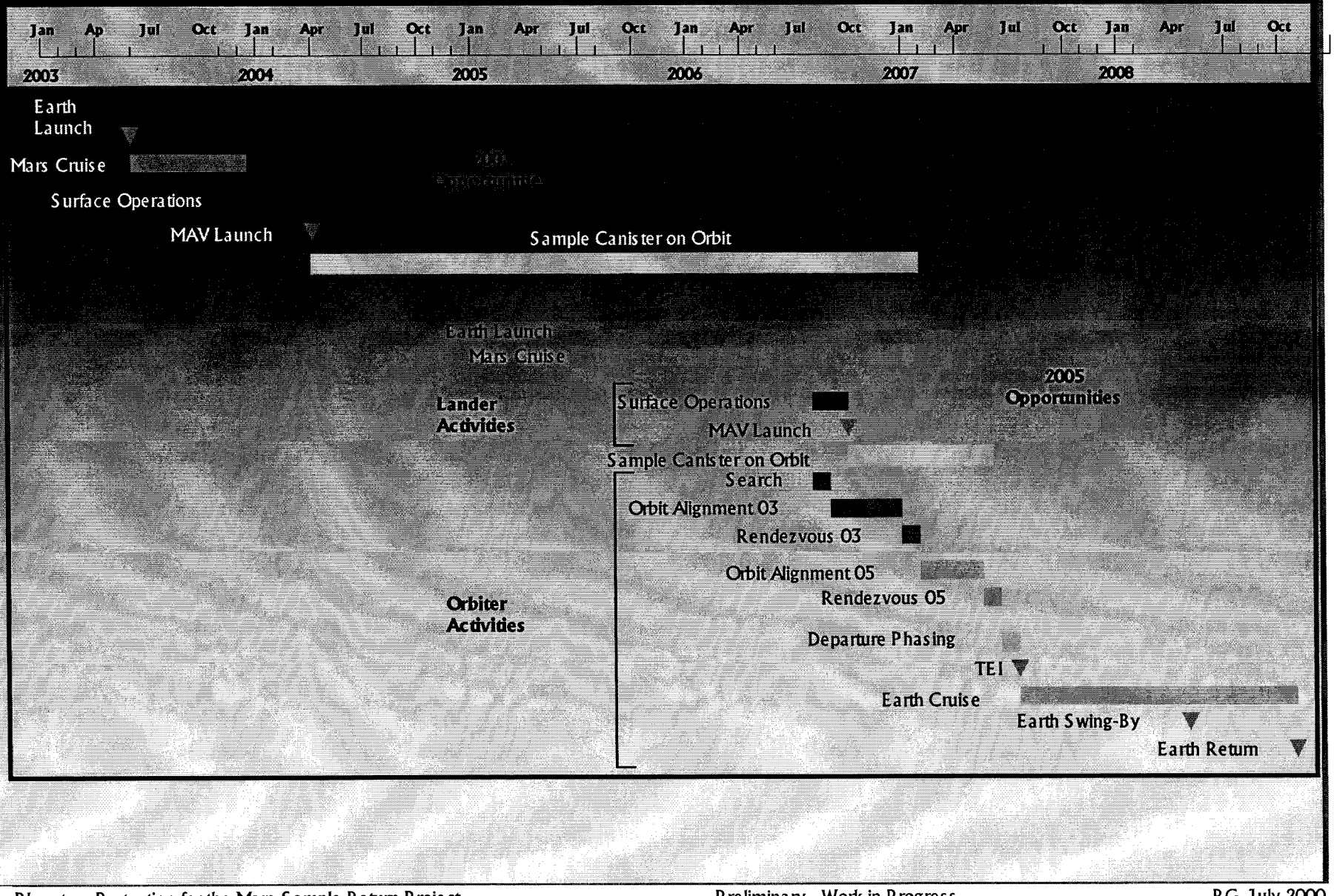
Introduction

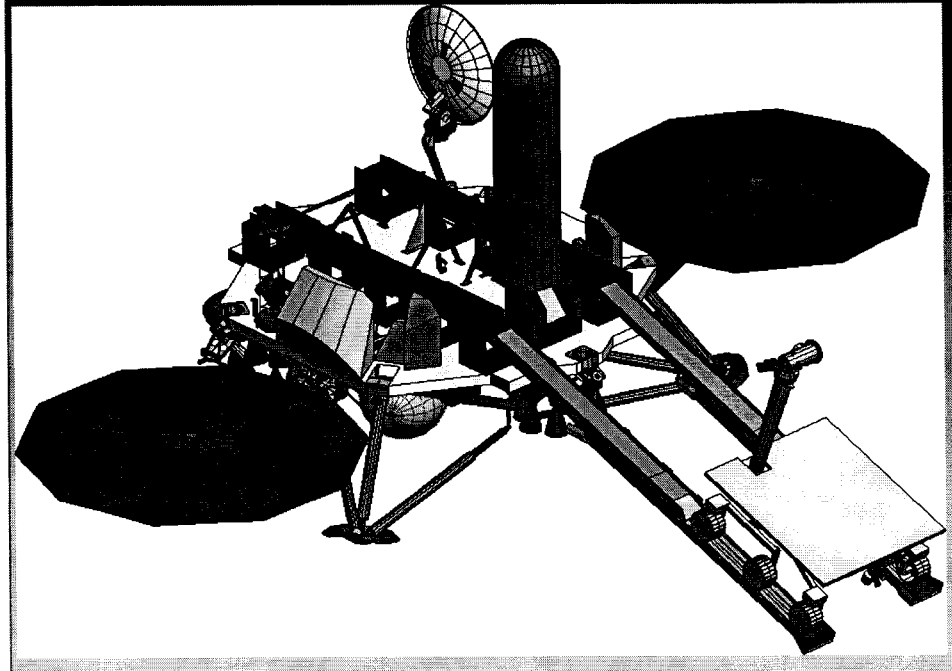
- **Status**
  - 03/05 Mars Sample Return project has been terminated.
  - Selected advanced technology development (ATD) tasks are being continued.
    - Mars Ascent Vehicle
    - Sample Rendezvous
    - Containment Assurance
    - Sample Transfer Chain
    - Contamination Control
  - The Mars Exploration Program is being replanned, results expected by end of September.
- **Presentation Content**
  - 03/05 Mars Sample Return concept
  - Planetary protection challenges and concepts
  - ATD plans


MARS SAMPLE RETURN
Mars Orbit
Mars Surface
D/A
Ar5
2003
2005
2008
Earth

2003/2005 Mission Event Timeline



Sample Transfer Chain



- Lander based sample transfer
  - Sample canister on lander
  - Sample transfer to Mars Ascent Vehicle (MAV)
  - Lander based sampler
    - Expecting ASI supplied drill
- Orbiting Sample (OS)
  - Sealed sample container
  - Solar power radio beacon
- Orbiter capture and transfer equipment

- Components across all flight elements
- Focus of planetary protection cleaning and sealing

Planetary Protection Challenges

- Assured Containment ($<10^{-6}$ probability of inadvertent release *)
  - Sample return capsule integrity
    - — Delivery to Earth entry corridor
    - — Earth entry vehicle (EEV)
    - — Sample capsule sealing and impact tolerance
  - No Martian materials on outside of capsule or EEV
    - — Break-the-chain-of-contact (BTC)
    - — Cross-contamination control
- Enable Hazard Detection Protocols
  - No roundtrip Earth microbes in sample ($<10^{-2}$ probability of a single unrecognizable Earth microbe in sample *)
    - — Contact hardware sterilization and cross-contamination control
    - or
    - — Sterilization of all landed elements (to Viking levels *)
  - Low noise
    - — Bulk cleaning and/or sterilization

** Draft requirement from NASA Planetary Protection Officer*

Containment Assurance ATD

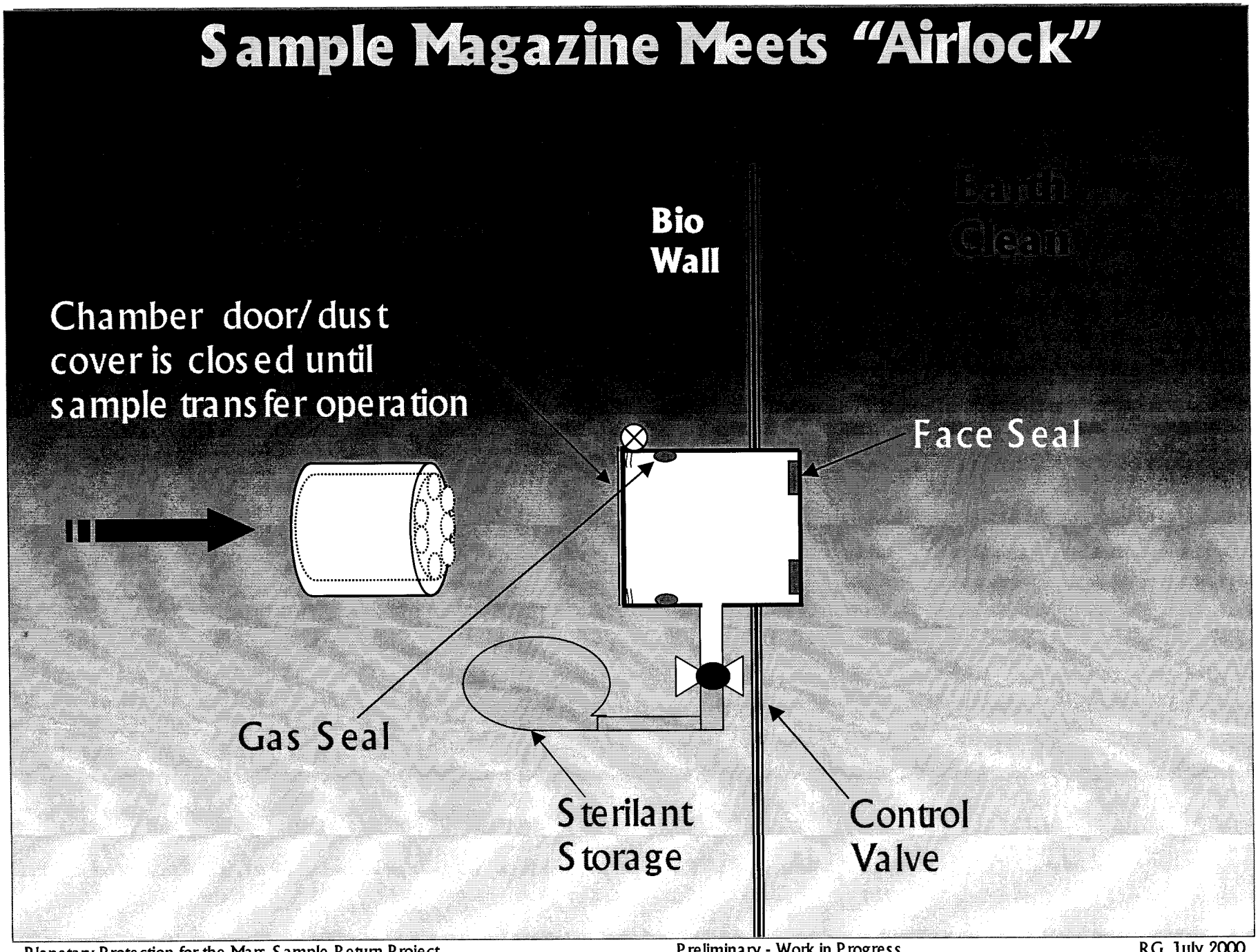
•Containment Assurance Risk Elements to be Addressed

1. OS not sealed or sealing cannot be confirmed by telemetry
2. OS exterior contaminated due to BTC failure
3. OS punctured by micrometeoroid
4. OS contaminated by dust from fairing
5. EEV lid not closed or closure cannot be confirmed by telemetry
6. CV not sealed or sealing cannot be confirmed by telemetry
7. EEV contaminated by dust during aerocapture/orbit or due to BTC failure
8. EEV damaged by meteoroid
9. Miss entry corridor due to Navigation failure
10. Miss entry corridor due to Orbiter failure
11. Miss entry corridor due to spin/eject failure
12. Miss entry corridor due to operations error
13. EEV failure due to inaccurate release state
14. EEV thermal protection system or structural failure
15. OS/CV breach on impact
16. Landed sample not recovered by NASA
17. Wave-off condition not detected or not acted upon by MOS
18. Waved-off or uncommandable orbiter/sample re-encounters Earth

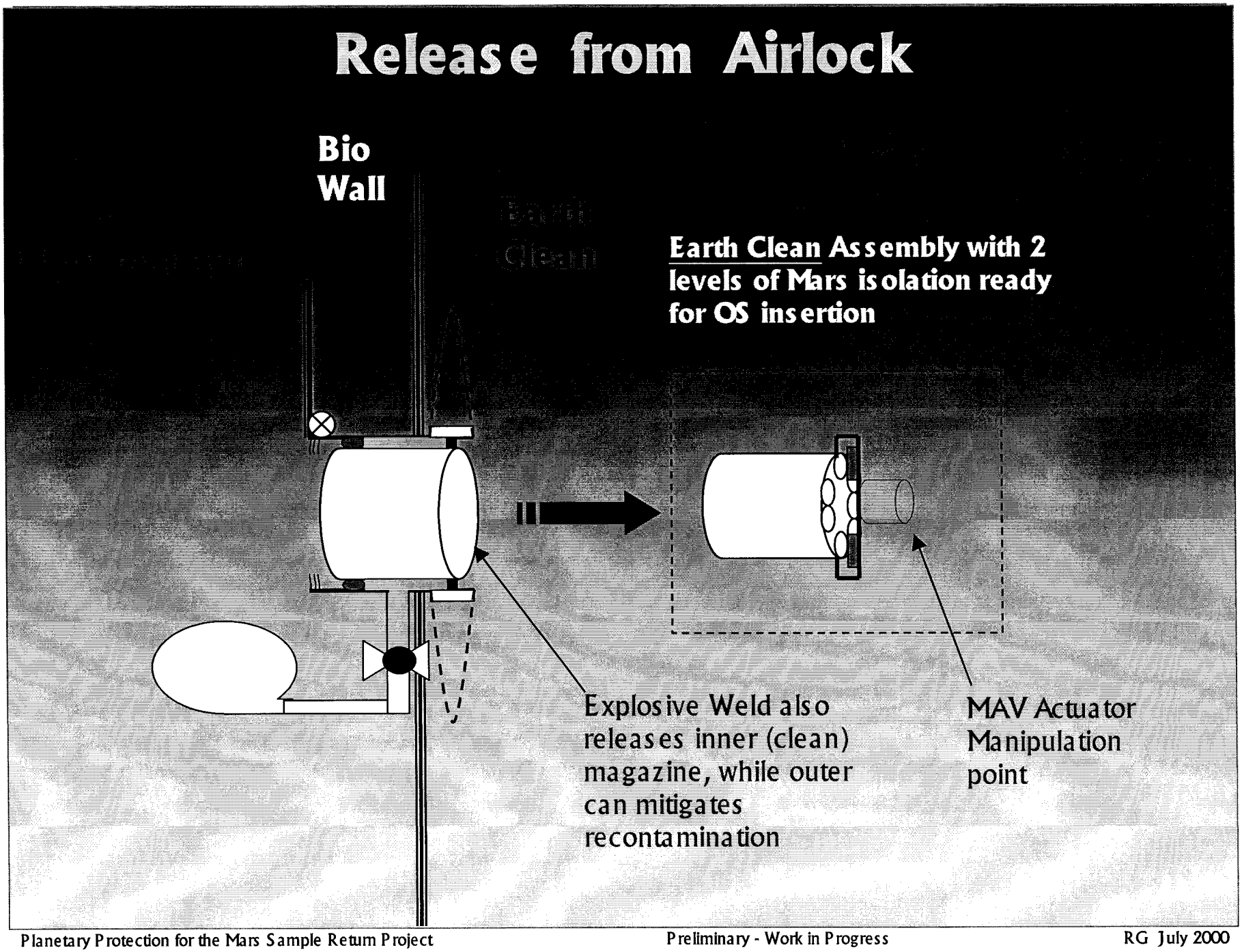
•Use Probabilistic Risk Assessment Techniques

- To quantify risk
- To prioritize elements for mitigation
- To compare mitigation options

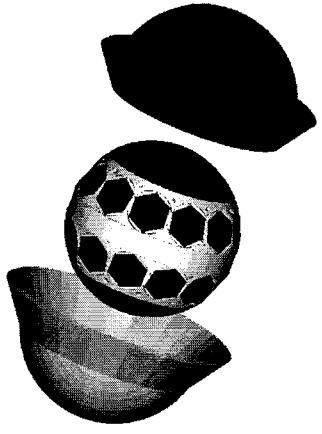
Sample Magazine Meets "Airlock"



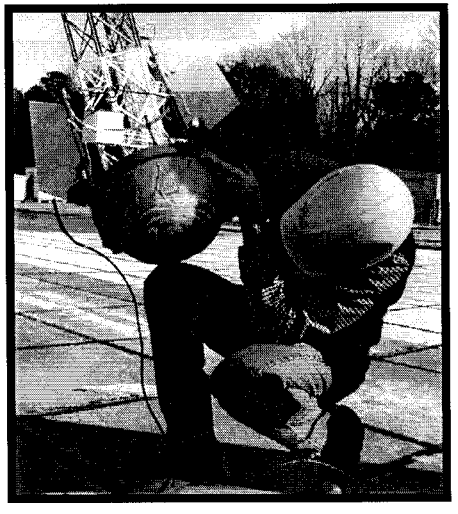
Release from Airlock



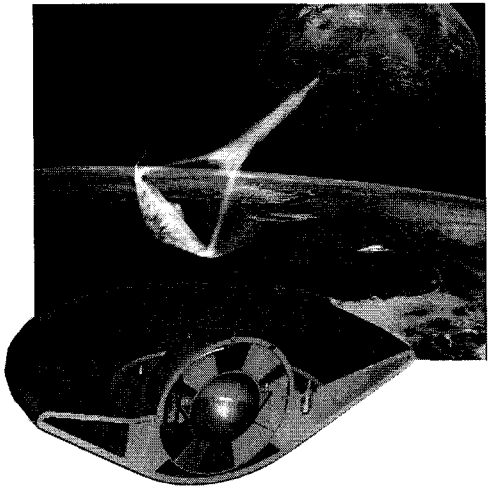
Sample Containment for Entry and Landing



- OS: Sealed inner shell, Rigid structural outer shell
- CV: Flexible, airtight, high strength shell, heat-sealed after EEV closure



- Impact sphere: High density carbon foam

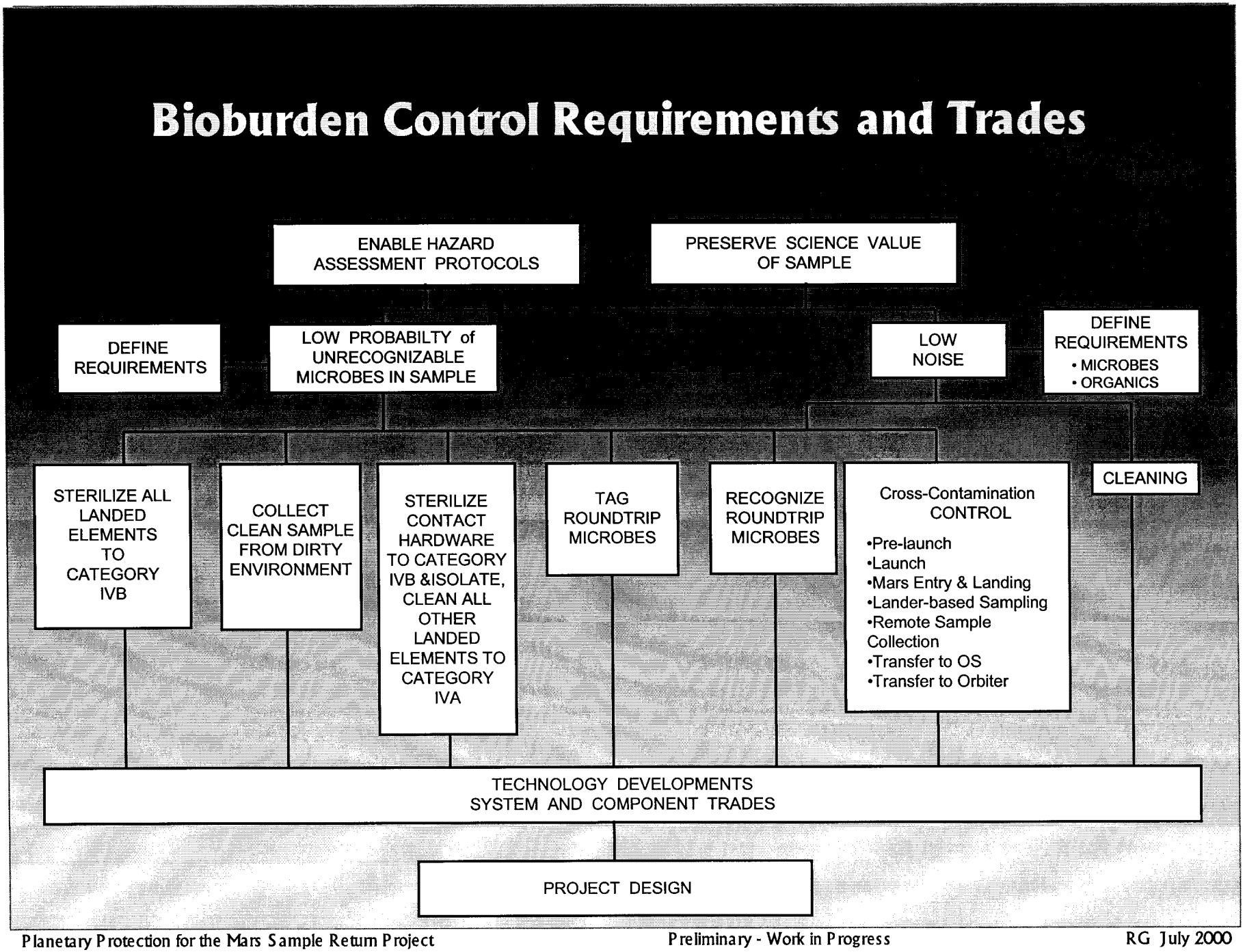


- EEV: Carbon phenolic heat shield, carbon-carbon structure

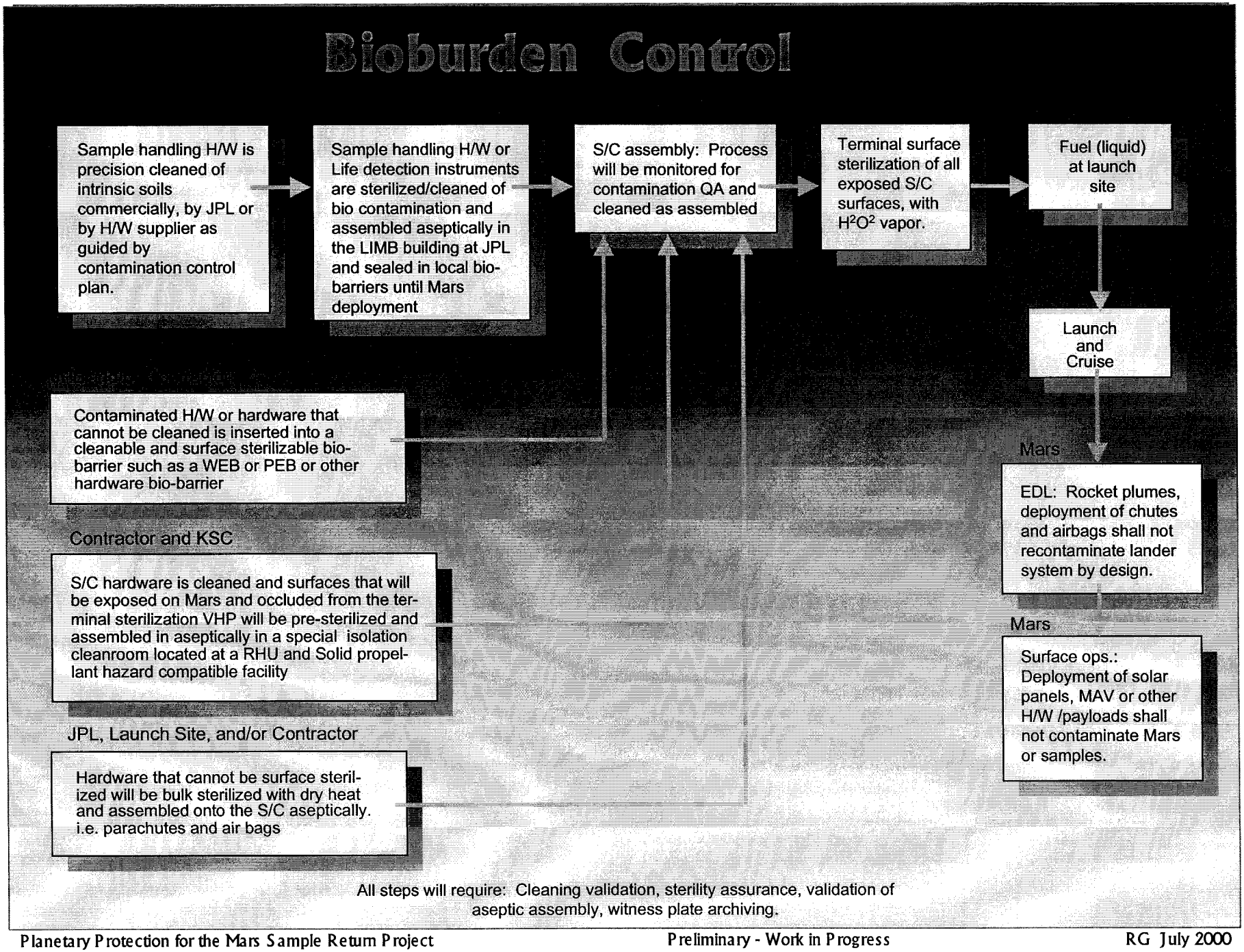
Development Process

- Integration of probabilistic risk assessment techniques within the risk-based design process.
- Use of heritage systems where appropriate, trading launch mass for demonstrated reliability.
- A rigorous analysis and ground-based test program focused on the key EEV risk elements:
- Development test program culminates in performance of an intgrated system validation flight test.

Bioburden Control Requirements and Trades



Bioburden Control



All steps will require: Cleaning validation, sterility assurance, validation of aseptic assembly, witness plate archiving.

Contamination Control Risk Elements

- Contamination control risk elements to be addressed

1. Poor understanding of costs, benefits, and risks to mission success of options for meeting contamination control requirements arising from planetary protection and science considerations.

2. We can't yet demonstrate overall effectiveness of cleaning/sterilization.

3. Applications of hydrogen peroxide for sterilization are not well understood for either sterilization performance or potential damage to S/C elements.

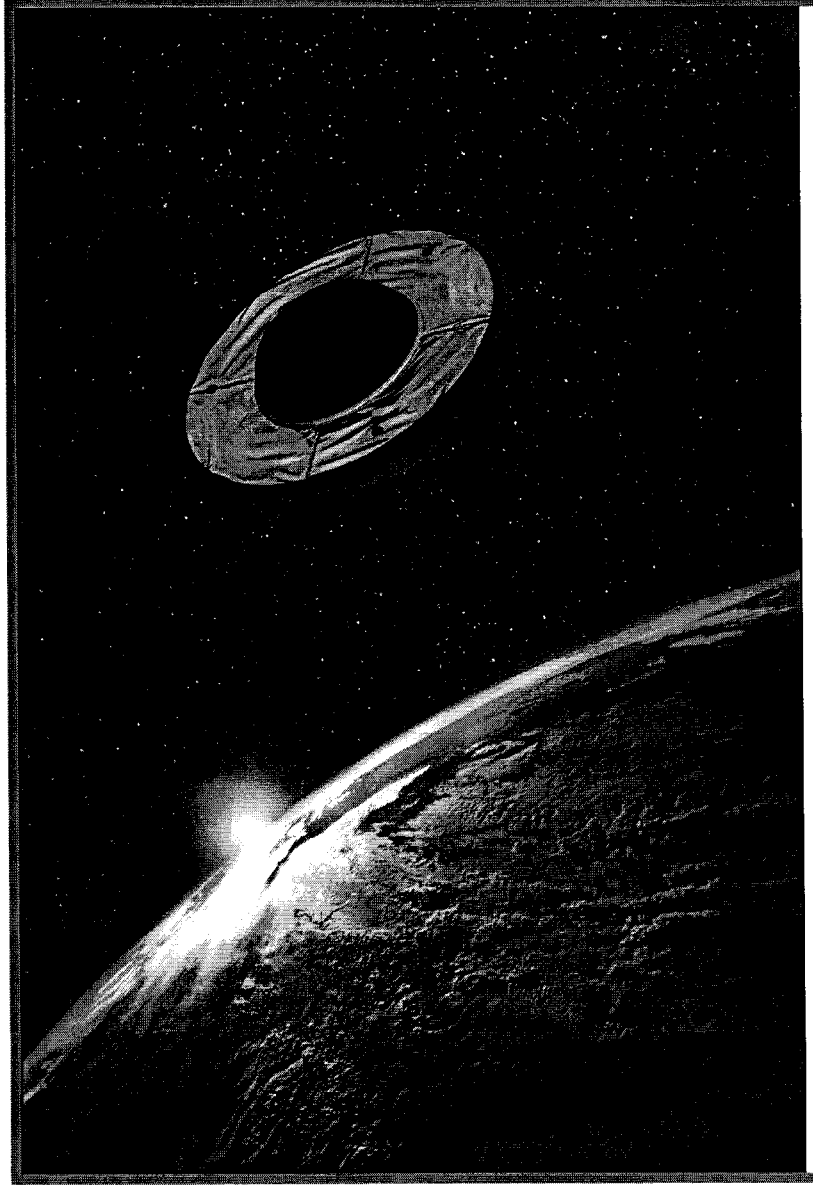
4. We don't yet know how to design a cleanable S/C or how to assemble a clean S/C from clean components and then maintain cleanliness.

5. We don't yet know how to collect clean samples in the vicinity of a dirty lander or rover.

Contamination Control Technology Plan

- **ATD**
  - Develop options
    - Terminal sterilization
    - Contact hardware sterilization/isolation
  - Validation/verification techniques
    - Modeling
    - Measurement
  - Hydrogen peroxide sterilization
    - Effectiveness
    - Compatibility with spacecraft components
  - Aseptic spacecraft assembly
  - Collecting clean samples from beneath dirty surfaces
- **Research**
  - Tagging round-trip organisms
  - Passive recognition of round-trip organisms

Conclusions



- Planetary protection for the 03/05 MSR Project posed many challenges
- Substantial progress was made prior to project termination but many open issues remained
- The current ATD task will attempt to resolve the most critical of these issues to facilitate a programmatic decision to proceed with MSR

The work to be described in this presentation was performed by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.